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Characterization of CHP Opportunities at U.S. Wastewater Treatment Plants

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Foreword

Preface

The U.S. Department of Energy (U.S. DOE) Office of Energy Efficiency and Renewable Energy (EERE) Advanced Manufacturing Office sponsored this report and the work described herein.

- Prepared for: U.S. Department of Energy (U.S. DOE) Office of Energy Efficiency and Renewable Energy (EERE) Advanced Manufacturing Office (AMO)
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Nomenclature or List of Acronyms

ADG	Anaerobic digester gas
CHP	Combined heat and power
EPA	Environmental Protection Agency
MGD	Million gallons per day
MW	Megawatt
ORNL	Oak Ridge National Laboratory
RPS	Renewable portfolio standard
WWTP	Wastewater treatment plant

Executive Summary

The U.S. Department of Energy (DOE) is actively engaged in activities aimed at addressing water system challenges related to energy. Initiatives such as the Water Security Grand Challenge, [1] Energy-Water Desalination Hub (Hub) [2] and Better Buildings Sustainable Wastewater Infrastructure of the Future (SWIFt) [3] Accelerator are driving innovative solutions for water systems to improve energy efficiency, enhance water security, and upgrade existing infrastructure. One proven approach to increasing energy efficiency and utilization of onsite generated biogas is combined heat and power (CHP) systems that provide a reliable and resilient source of power for wastewater treatment plants.

Wastewater treatment plants (WWTPs) with anaerobic digesters have long been identified as ideal locations for combined heat and power (CHP) systems. WWTPs that use anaerobic digestion have consistent electric and thermal loads that can support on-site CHP, and the digestion process generates a renewable, methane-rich biogas (anaerobic digester gas, or ADG) that can be used to power CHP systems. These systems can provide enhanced on-site reliability and resilience, reduce greenhouse gas (GHG) emissions, and lower energy costs for the water treatment facility. Although CHP installations at U.S. WWTPs have been increasing in recent years, untapped potential for additional CHP at these facilities remains. While the majority of WWTPs throughout the U.S. are located at industrial manufacturing facilities, they are typically small in scale and their waste streams may not contain the amount of organic matter required for anaerobic digestion. This paper highlights the current benefits that ADG CHP can provide, identifies critical implementation factors for continued success, and estimates the technical potential for new CHP installations given the strong market drivers present at municipal WWTPs. Overall, this study estimates that there is over 260 MW of CHP technical potential at roughly 1,015 municipal WWTPs in the U.S. today.

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[1] DOE Launches Water Security Grand Challenge, 2018. Available at: https://www.energy.gov/articles/doe-launches-water-security-grand-challenge.

[2] Department of Energy Announces $100 Million Energy-Water Desalination Hub to Provide Secure and Affordable Water, 2018. Available at: https://www.energy.gov/articles/department-energy-announces-100-million-energy-water-desalination-hub-provide-secure-and

[3] U.S. DOE Better Buildings, Sustainable Wastewater Infrastructure of the Future (SWIFt). Available at: https://betterbuildingsinitiative.energy.gov/accelerators/wastewater-infrastructure

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Current State of CHP, Anaerobic Digestion, and WWTPs

Combined heat and power (CHP) is the production of electricity and useful thermal energy from a single fuel source. CHP technologies can use a variety of fuels (natural gas, biomass, biogas, coal, oil) to generate power and thermal energy at the point of use, increasing the overall system efficiency when compared to separate heat and power production. CHP systems typically consist of a prime mover (engine or turbine), heat recovery system, generator, and water loops (See Figure 1).[4] While many CHP systems rely on natural gas as the primary fuel, the onsite production of renewable biogas can assist WWTPs in the move to become energy producers, instead of relying on the electric grid and an external fuel supply. WWTPs that utilize anaerobic digestion to produce ADG have the ability to become energy independent and increase the resiliency and security of their critical operations by installing CHP.

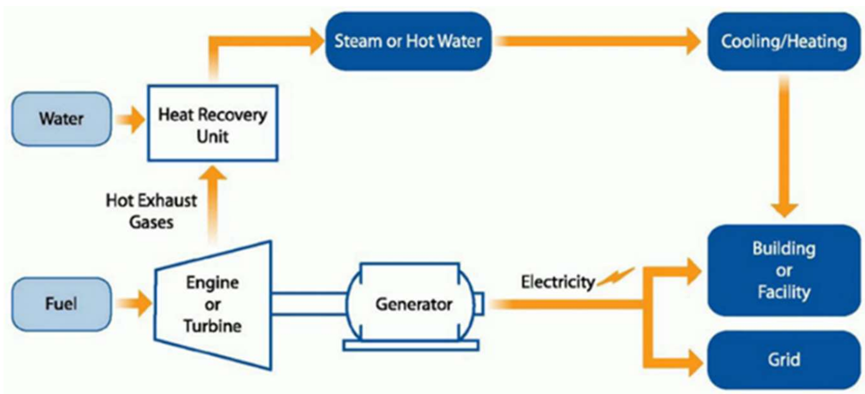

Figure 1. Reciprocating Engine or Gas Turbine CHP System with Heat Recovery

Anaerobic digesters at WWTPs are large, sealed, heated tanks that allow anaerobic bacteria to digest and break down wastewater sludge. A cross-section diagram of a digester tank is illustrated in Figure 1 on the following page. As sludge from the treatment plant is pumped into the tank, bacteria consumes the waste and releases methane gas as a byproduct. Effluent gas from the tank is collected, consisting mostly of methane and carbon dioxide. Most states require this gas to be either flared or utilized for on-site electric/thermal requirements to reduce greenhouse gas emissions. [5]

In the U.S. today, there are over 14,000 municipal WWTPs, and at least 1,286 use anaerobic digesters that produce ADG (WEF 2016). However, only 184 of these facilities currently utilize their biogas for CHP (U.S. DOE CHP Installation Database 2018).[6] Around one third of the facilities flare their gas, while the remaining facilities utilize their ADG to heat the digester tanks. WWTPs require a substantial amount of electric power, and anaerobic digesters need a constant heat source to maintain internal digester temperatures near 98˚F for optimal bacteria activity and biogas production. ADG CHP systems can provide an economical, efficient, and sustainable solution for heat and power requirements at WWTPs (WEF 2016).

[4] For more information on CHP system configurations, please visit: https://betterbuildingssolutioncenter.energy.gov/chp/basics
[5] While both methane and carbon dioxide are greenhouse gases, methane has a global warming potential (GWP) of 21 times that of carbon dioxide. Therefore, sources of methane emissions are usually required to flare the methane, converting it into carbon dioxide.
[6] Of the 222 WWTPs with CHP installed, 184 use ADG as the primary CHP fuel source.

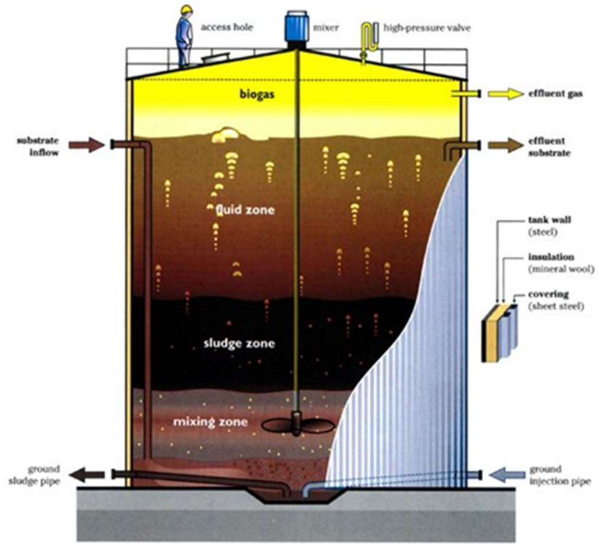

Figure 2. Anaerobic Digester (Source: HTI Tanks, LLC)

CHP at WWTPs: Current Status and Market Drivers

With consistent electric and thermal loads to serve, a need for energy resiliency, a free source of renewable fuel, and the standardization of biogas pretreatment methods, many WWTPs with anaerobic digesters are successfully installing CHP systems. This has resulted in the total number of CHP systems at U.S. WWTPs more than doubling from 2010-2017. During this recent eight-year period, 126 new CHP systems were installed at municipal WWTPs throughout the U.S., adding more than 253 MW of CHP capacity (see Figure 3).

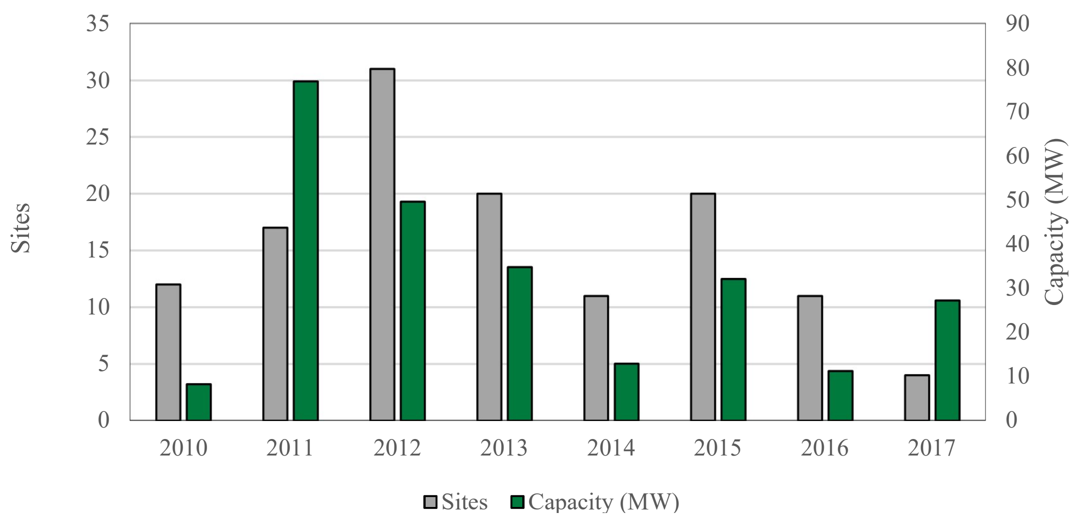

Figure 3. WWTP Site and Capacity Additions by Year (2010-2017)

Since 2010, the majority of WWTP sites have installed reciprocating engines as their prime mover technology due to the flexibility in sizing reciprocating engines and economic/efficiency advantages at lower capacities. Microturbines have been used for several smaller CHP installations, partially due to their increased tolerance for siloxanes compared to engines (ORNL 2015). Combustion turbines, which are best-suited for large-scale operations, make up the largest portion of recent capacity additions at WWTPs with a relatively low number of installations. Other technologies such as steam turbines and fuel cells have also been applied in recent WWTP CHP installations throughout the country (Figure 4).

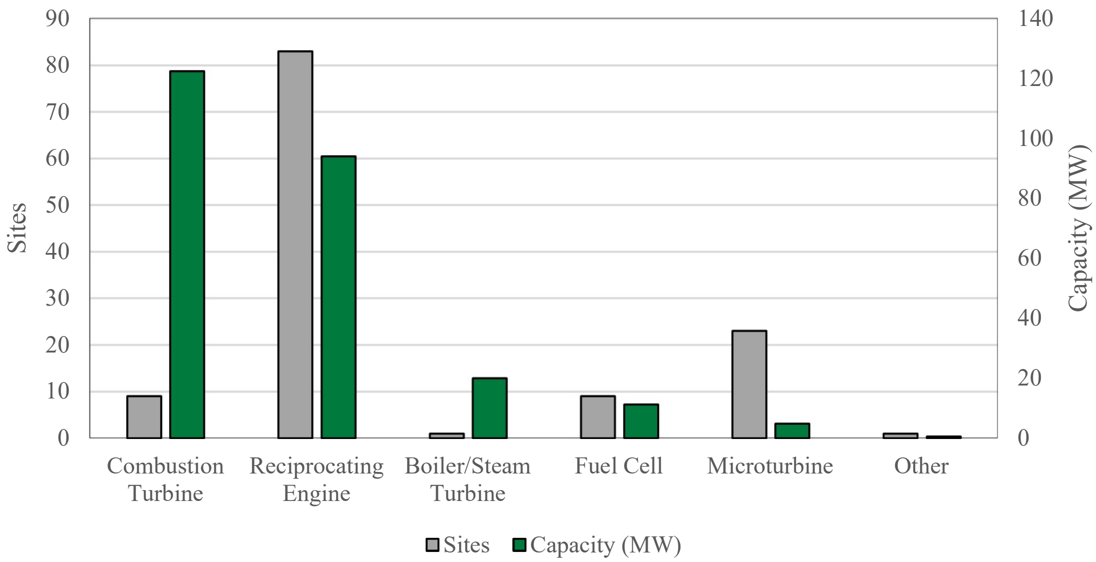

Figure 4. WWTP Site and Capacity Installations by CHP Technology (2010-2017)

Analyzing the data for WWTP CHP installations over this timeframe can provide insight into the recent market for ADG CHP.

- Reciprocating engines accounted for nearly two-thirds of WWTP CHP site additions and over one-third of capacity additions from 2010 through 2017.[7] Reciprocating engines are a good fit for many potential WWTP installations due to the range of available system sizes, high electric efficiencies, and the ratio of available power to thermal energy.
- The Western region had the largest increases in WWTP CHP capacity over this period, with 41% of total U.S. capacity additions.[8] There were 25 WWTP CHP installations in California between 2010 and 2017, two of which were over 20 MW in size (CHP Installation Database 2017).
- Roughly 63% of new WWTP CHP system installations in this time frame were under 1 MW, although this size range only accounted for 12% of total capacity additions (CHP Installation Database 2017).

The rapid pace of CHP deployments at WWTPs is expected to continue, even though many favorable facilities (i.e. large WWTPs in areas with high electricity prices) have already installed CHP. Over 80 percent of WWTPs with anaerobic digesters have not installed CHP systems, with most of them only utilizing their ADG for boiler fuel. However, CHP installations tend to be more beneficial, considering the long-term competitive advantage that ADG CHP can have over retail electricity purchases. In addition to favorable economics, there are several additional drivers that are causing WWTP operators to consider installing CHP.

[7] See the DOE Fact Sheets at https://energy.gov/eere/amo/combined-heat-and-power-basics for information on prime mover technologies that can be used for CHP.
[8] Based on DOE CHP Technical Assistance Partnership regions

Case Study: Albert Lea Wastewater Treatment Facility

Project Overview

Alberta Lea, Minnesota installed a 120 kW microturbine CHP system in its WWTP in 2003 to provide heat to the facility and backup electric power. The CHP system is able to provide temperature control for the anaerobic digester and serve a portion of the facility space heating needs. The 120 kW of electric generation provides roughly 25% of the facility's electric demand, and the capability to power all critical systems in the event of a grid outage.

Project Facts

- **4.3 MGD** average flow rate
- **120 kW** of CHP generating capacity – (4) 30 kW microturbine units
- **28 MMBtu/day** – heat recovery rate from CHP
- **$60,000-$90,000** annual energy savings, **$250,000** total project cost

Albert Lea Wastewater Treatment Plant Anaerobic Digester

Critical Factors for CHP Implementation

Critical factors that indicate the viability of CHP at wastewater treatment plants include:

1. **WWTP uses anaerobic digestion for wastewater treatment.** There are different methods of treating wastewater in order to remove harmful contaminants; however, biogas is only produced in anaerobic digesters. Plants that use other methods do not have the on-site fuel supply or the thermal requirements to support CHP. Some WWTPs with aging treatment equipment or insufficient capacity for growing wastewater loads may decide to change treatment methods, and the potential for ADG CHP can be a driver for this decision. However, facility owners are not likely to switch from aerobic to anaerobic digestion based solely on CHP opportunities. These decisions are primary due to costly equipment upgrades that would be required (Metcalf & Eddy 2003).

2. **WWTP processes at least 2 million gallons of wastewater per day (2 MGD).** A recent Oak Ridge National Laboratory study showed that on average, for each MGD of wastewater processed by treatment plants, an engine with 30% electric efficiency can generate about 27 kW of electricity from the resulting ADG (ORNL 2015). That means a WWTP processing 1 MGD could potentially support a 30 kW microturbine or engine. With the high per-kW costs of both CHP and gas treatment equipment at this size, economics are not very favorable in many cases, so a 2 MGD plant supporting a CHP system larger than 50 kW would be a more feasible minimum size. In general, the larger the treatment plant, the more favorable the economics for CHP.

3. **WWTP treats ADG to remove hydrogen sulfide and siloxanes.** Many early ADG CHP projects learned that proper gas treatment and processing is a necessity. Hydrogen sulfide and siloxanes found in ADG can cause fouling and damage to equipment components, leading to high maintenance costs and extended equipment downtime. While treatment equipment can be expensive, it is worth the investment in the long-term (Brown & Caldwell 2010).[9]

4. **Location in a high electricity price region.** WWTPs in locations where electricity is expensive will be able to recover the cost of CHP equipment more quickly than those in areas with low electricity

[9] The next section, *Biogas Treatment,* discusses siloxanes and hydrogen sulfide in more detail.

prices. Although there are no fuel costs for ADG CHP systems, maintenance costs are higher than natural gas systems, and the initial capital cost can be double that of a comparable natural gas system due to the required gas treatment equipment. Significant energy bill savings are critical for recovering the large investment.

Anaerobic digestion is most commonly used at large municipal WWTPs, and is generally the preferred method for treating large volumes of wastewater. In addition to municipal wastewater, other local waste streams can be added to a WWTP digester in order to maximize ADG yield. These could include waste streams from breweries, food processing plants, dairy production, or external sources of fats, oils, and grease (FOG). Digesters become more economical as they increase in size, and they are effective at eliminating odors and breaking down sludge waste at a large scale. WWTPs with anaerobic digesters produce ADG, which can be considered a renewable fuel as it is derived from biomass waste. Several states offer incentives for ADG-fueled CHP as biogas is included as a renewable fuel in many state renewable portfolio standards (DSIRE 2016). At a national level, Renewable Identification Numbers (RINs) are also available from ADG production (WEF 2016).

When paired with CHP, the cost for anaerobic digesters tends to range from $1,000 to $3,000 per kW, with the potential for higher per-kW costs if the CHP unit is not adequately sized to the full digester capacity (ORNL 2015). This is in addition to the CHP and gas treatment installation costs, which add anywhere from $2,000 to over $6,000 per kW depending on the technology and system size (ORNL 2015). If a WWTP currently has an anaerobic digester installed, the total required investment (and the resulting payback period length) could be reduced by 33 percent or more (ORNL 2015).

Proper CHP sizing is important for ADG CHP projects. CHP systems must match both the facility's steady electric load and the available fuel (digester gas). In cases where the available digester gas fuel is not sufficient, natural gas can be used as a secondary fuel, or other waste streams can be added to increase biogas production. For example, the City of Gresham, Oregon WWTP[10] adds nutrient rich feedstock's from FOGs including urban grease trap and cooking waste to its digesters. The acceptance of these wastes generates tipping fees that improve the economics of WWTP CHP installations while increasing ADG productivity.

Even though biogas treatment equipment requires a larger capital investment compared to traditional CHP applications, the annual operating costs are lower due to avoided fuel costs and many facilities are able to accept longer payback periods because they have long-term planning horizons. For example, municipal wastewater treatment plants, such as the Blue Plains plant in Washington DC (shown in Figure 5), tend to accept lower rates of return compared to typical commercial and industrial customers that are driven by near-term profits.

[10] See project profile for *The City of Gresham Cogen & FOG Receiving Station Expansion Project* http://americanbiogascouncil.org.

Figure 5. Two of the Four Anaerobic Digesters at the Blue Plains WWTP in Washington, DC. Source: CDM Smith

Biogas Pretreatment

When digester gas was first used to generate power with CHP engines in the 1980s and 1990s, it quickly became apparent that corrosive hydrogen sulfide needed to be removed from the gas. In addition to increasing maintenance requirements and shortening engine lifespans, the presence of hydrogen sulfide leads to post-combustion sulfur dioxide emissions. As a result, system operators began passing the biogas through vessels containing wood chips or clay pellets embedded with hydrated ferric oxide. This captures the sulfur in the gas by creating solid iron sulfide compounds. More recently, iron oxide sorbent systems have been developed to remove harmful sulphur compounds in digester gas. Another method of methane treatment gaining acceptance is the use of hydrogen sulfide consuming bacteria contained in a flow chamber (Syed et al., 2006). In general, hydrogen sulfide levels in ADG must be reduced below 200 parts per million before it is acceptable as fuel in any type of CHP system (Brown & Caldwell 2010).

While the importance of hydrogen sulfide removal was discovered quickly, it took some time for operators of ADG CHP systems to recognize the significance of siloxanes. Siloxanes, found in many hair and skin care products, are not digested by the anaerobic bacteria. They produce a white glass-like deposit on engine and turbine components. The build-up of siloxane deposits eventually leads to efficiency reductions and failure of prime mover system components. Removing the deposits can be extremely difficult, causing large increases in maintenance costs (ORNL 2015).

Siloxanes can be removed through refrigeration combined with condensation, or from adsorption onto silica gel-based media, absorption onto activated alumina, or absorption onto activated carbon media. Activated carbon filters are currently the most common method of siloxane removal, but to date, no solution has proven to be the most robust method. While most filtration systems are relatively simple and can be safely disposed of in municipal landfills, the equipment costs can be high, especially for smaller ADG CHP installations. Different prime mover manufacturers have varying limits for tolerable biogas siloxane levels (Brown and Caldwell 2010).

Struvite formation can also be an issue in WWTPs with anaerobic digesters. Given the right nutrient concentrations, pH, and temperature, struvite can form in anaerobic digesters or within accessory plant equipment such as pumps, valves, or pipe connections. Struvite buildup can cause significant equipment and maintenance costs if not properly dealt with in a timely manner. A common method to prevent the struvite formation is the removal of phosphate ions in order to limit harmful and costly buildup (Fattah 2012).

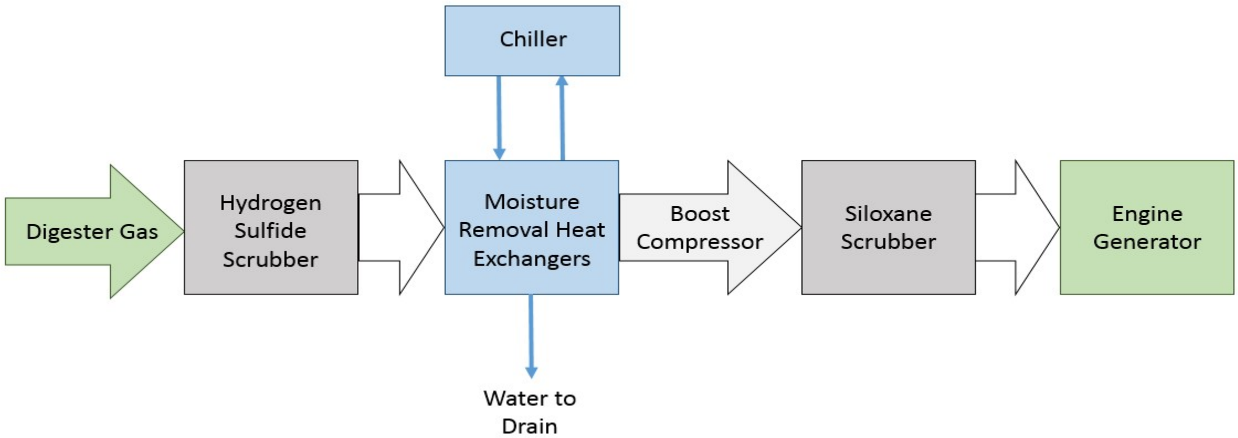

Figure 6. The Gas Scrubbing Train for Biogas Pretreatment

Many early ADG projects at wastewater treatment plants experienced damage to CHP equipment due to the lack of proper hydrogen sulfide and/or siloxane removal. Lessons have been learned, and new ADG projects implement a full, standardized pretreatment process of hydrogen sulfide removal, moisture removal, and siloxane removal. This is sometimes referred to as the "gas scrubbing train", shown in Figure 6. Gas pretreatment equipment increases CHP installation costs, and some additional maintenance is required. However, effective gas treatment has proven to be critical for long-term success, and with a no-cost fuel source, ADG CHP can provide attractive life cycle costs for many WWTPs (ORNL 2015).

Drivers for ADG CHP

Reliable and resilient power is of critical importance to wastewater treatment plants and the communities they serve. If an extended power outage caused a treatment facility to become inoperable, communities would face serious health and sanitation issues. Power outages affecting WWTP's during Hurricane Sandy allowed 11 billion gallons of untreated and partially treated sewage to flow into nearby bodies of water (Climate Central 2013).

ADG CHP is beneficial to the environment as efficient CHP utilization results in the lowest net greenhouse gas emissions compared to both flaring and utilizing digester gas for heat. It is estimated that CHP systems save the United States 1.8 quads of fuel each year, avoiding 241 million metric tons of CO2 emissions annually. [11]

The primary drivers for ADG CHP at WWTPs include:

- Power Reliability and Resiliency: WWTPs remain operational during power outages

[11] Based on DOE CHP Installation Database. https://www.energy.gov/eere/amo/articles/more-550-megawatts-new-combined-heat-and-power-capacity-added-united-states-puerto

- Environmental Benefits: Greenhouse gas reduction, both compared to flaring and to separate heat and utility power; renewable fuel source
- Renewable Portfolio Standards: Currently 39 out of 41 states with RPS programs include ADG or biogas as a qualifying fuel, allowing ADG CHP systems to earn renewable energy credits[12]
- Incentive Programs: Many state or utility incentive programs include grants, rebates, or other benefits for new CHP installations using renewable fuels
- Economics: The economics for ADG CHP are often favorable, especially when considering life cycle costs

With the many benefits offered by ADG CHP, over 200 wastewater treatment plants with anaerobic digesters have invested in CHP systems, with most of them fueled by ADG (U.S. DOE CHP Installation Database 2018).[13] However, the over 80 percent of WWTPs with digesters have not yet installed CHP, leaving significant untapped potential in this sector.

Estimating the Technical Potential for New ADG CHP Projects

There are approximately 75,000 wastewater treatment plants in the U.S., with 80 percent located at industrial facilities and 20 percent operated by municipalities. Of the 60,000 industrial treatment plants, only a small percentage are good candidates for CHP. The majority of these industrial treatment plants are relatively small in comparison to municipal WWTPs, and most of them treat industrial wastewater that lacks the organic compounds necessary for anaerobic digestion. In the industrial sector, only large treatment plants that treat organic waste streams in the food processing, pulp and paper, and chemicals industries can support ADG CHP (ORNL 2015).

There are two different methods for estimating CHP potential at WWTPs:

- Utilizing ADG flow rates
- Utilizing the electric and thermal energy requirements of the sites.

Estimating CHP Capability with ADG Flow Rates

The technical potential for ADG CHP can be calculated based on the estimated digester gas production, with the assumption that all the gas is used to fuel a CHP system and all the resulting electricity is used on-site. This method uses the average wastewater flow rates from individual WWTPs to estimate potential ADG production, and the potential for ADG-fueled power generation. Multiplying the average wastewater flow rate (million gallons/day, or MGD) by the average ADG power production rate (about 27 kW per MGD) yields a potential capacity (kW) figure that can be calculated for each treatment plant (ORNL 2015).

[12] Renewable energy credits, also known as REC's, are tradeable credits obtained from the generation of 1 MWh of qualified renewable energy. Electricity generated from ADG qualifies as renewable fuel in nearly all states with an RPS and can be a significant revenue source for WWTP's utilizing ADG for electricity generation.

[13] Of the 222 WWTPs with CHP installed, 184 use ADG as the primary CHP fuel source.

Calculation for estimated CHP capacity (kW) at an ADG-fueled WWTP:

$$Average\ Wasewater\ Flow\ Rate\ \left(\frac{Million\ gallons}{day}\right) x\ Average\ ADG\ Power\ Production\ Rate\ \left(\frac{27\ kW}{MGD}\right)$$
$$= Estimated\ CHP\ Technical\ Potential\ (kW)$$

The 2015 study by Oak Ridge National Laboratory (ORNL) estimated the technical potential for CHP from ADG produced at WWTPs, limited to sites that process at least 1 million gallons of wastewater per day. The total technical potential for the U.S. was estimated to be 717 MW at 3,394 sites, with about 90 percent of the potential coming from municipal WWTPs. However, this technical potential estimate included WWTPs that incorporate treatment methods other than anaerobic digestion. Facilities that treat their wastewater with other methods do not produce any biogas, and they are unlikely to switch treatment methods based solely on the potential for CHP.

WWTPs with technical potential for ADG CHP should be limited to sites that currently have anaerobic digesters installed. Although data on industrial WWTPs with anaerobic digesters are lacking, the EPA Clean Watersheds Needs Survey (CWNS)[14] contains information and statistics on all municipal WWTPs. However, recent updates to the CWNS data were found to be inconsistent with previous versions of the survey, with fewer sites reported as using anaerobic digestion.

As an alternative to CWNS, the Water Environment Federation has collected and verified data on ADG utilization for municipal WWTPs with anaerobic digesters, primarily focusing on facilities that process more than 1 million gallons per day. Applying the method for estimating technical potential established by ORNL to the most recent data on WWTPs of ADG from the Water Environment Federation (WEF 2016) can be used to estimate the technical potential for new CHP installations at municipal WWTPs in the U.S. This method resulted in 264 MW of technical potential for ADG CHP at 1,015 sites that do not currently utilize ADG for CHP.[15] However, the WWTP data from the Water Environment Federation is work in progress and not all facilities with digesters are included.

Estimating CHP Capability with Electric and Thermal Site Requirements

Another method of estimating the technical potential for CHP at WWTPs evaluates the ability of CHP technologies to serve customer energy needs. Both the estimated electric and thermal requirements of a facility are considered when calculating the CHP electrical generation potential. For WWTPs, CHP capabilities based on ADG flow rates tend to match up well with facility thermal needs and baseload electricity requirements.

Table 1. Municipal WWTP Technical Potential by State (DOE/ICF).

State	Sites	Capacity (MW)
California	145	36
Texas	103	22
Pennsylvania	100	14
Ohio	70	13
New Jersey	70	10
New York	57	16
Florida	35	19

[14] The CWNS provides an assessment of the capital investment necessary for public WWTPs to meet the goals of the Clean Water Act, and is available at https://www.epa.gov/cwns

[15] Note that data collection on municipal WWTPs with ADG is ongoing. This calculation does not rely on complete sample, so the total number of sites with digesters is slightly lower than previous estimates, such as the 2015 ORNL study.

The "site requirements" method was used in a 2016 DOE report on the technical potential for CHP applications at all types of commercial, institutional, and industrial facilities, with a lower limit of 50 kW for CHP size (ICF International 2016). WWTPs were included, but only those using anaerobic digestion, as facilities utilizing different treatment methods do not have sufficient thermal loads to support CHP. CHP size for each WWTP was estimated based on a correlation of wastewater flow rate and facility energy requirements. In the 2016 report, 262 MW of the total technical potential for municipal WWTPs in the U.S. was estimated at 1,303 sites (ICF International 2016). While there are some differences based on the data sets, methodologies and assumptions, this estimate is largely in agreement with the estimate based on ADG flow rates.

States with large populations or high population densities typically have the highest amount of CHP technical potential at WWTPs (see Table 1). Roughly 45% of individual site technical potential and 50% of technical potential in terms of capacity (MW) are located in the top seven states for CHP potential at WWTPs.

Summary of Technical Potential Estimates

Estimates of the potential of ADG CHP at WWTPs are provided in Table 2, Technical Potential Estimates for ADG CHP at WWTPs.

Table 2. Technical Potential Estimates for ADG CHP at WWTPs

Source	Method	WWTPs analyzed
ORNL/RDC (2015)	CHP size based on wastewater flow data (CWNS) and estimated ADG production rates	All WWTPs >1 MGD, including those not using anaerobic digestion
DOE/ICF (2016)	Estimated baseload site energy requirements, limited to WWTPs producing ADG (CWNS)	Municipal WWTPs with digesters, with loads to support >50 kW CHP
ICF/Water Environment Federation (2018)	ORNL method, limited to WWTPs producing ADG (WEF)	Municipal WWTPs with digesters, >1 MGD verified by WEF

Figure 7 shows the estimated number of WWTPs in the U.S. based on the available information on WWTPs, and a consolidation of the three data sources from Table 2. WWTP figures are narrowed down from all treatment plants to facilities that have digesters that are likely to support CHP, and those that already have CHP installed.

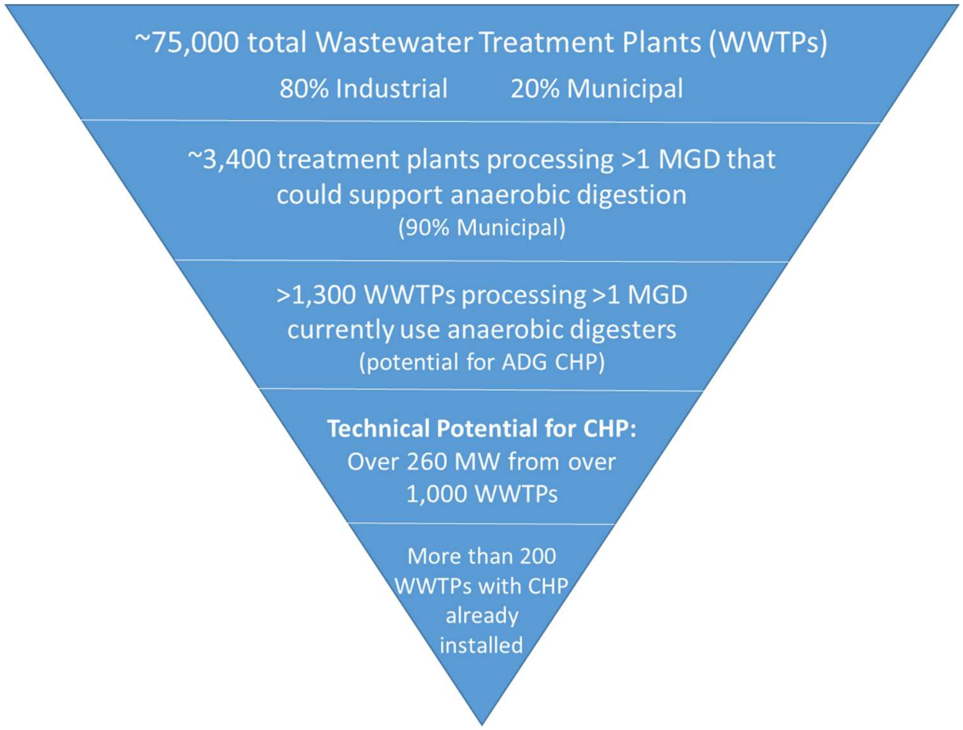

Figure 7. Characterization of U.S. WWTPs with CHP Potential

The total technical potential for CHP at all types of commercial, industrial and institutional facilities in the U.S. has recently been estimated to be 241 GW at 291,902 sites (DOE 2016). Although the total technical potential for ADG CHP at WWTPs may be relatively small in comparison to other applications (only 1 percent of the total capacity and 4 percent of the total sites), a higher percentage of these sites are likely to move forward with CHP due to the availability of a free renewable fuel, municipal sustainability initiatives and greater emphasis on life cycle costs instead of payback periods. Since 2010, CHP installations at WWTPs have accounted for 5 percent of new CHP capacity and 11 percent of site additions (U.S. DOE CHP Installation Database 2016).

Conclusions

Many WWTPs are benefiting from CHP installations and many more have strong potential. In order for a wastewater treatment plant to benefit from ADG CHP, several critical factors must be achieved. The four most important factors for successful ADG CHP installations are:

1. WWTP uses anaerobic digestion for wastewater treatment, producing methane-rich ADG
2. WWTP processes at least 2 million gallons of wastewater per day (2 MGD)
3. WWTP properly treats ADG to remove hydrogen sulfide, siloxanes, and other harmful components such as struvite
4. Electricity rates: economic payback and rate of return are heavily dependent on electricity rates

The number of CHP installations at WWTPs in the U.S. more than doubled from 2010 to 2017, with over 200 total systems currently in operation, and most using ADG as their primary fuel source. The primary drivers for ADG CHP at WWTPs include:

- **Power Reliability and Resiliency:** WWTPs remain operational during power outages

- **Environmental Benefits:** Greenhouse gas reduction, renewable fuel source
- **Renewable Portfolio Standards:** Currently 39 out of 41 states with RPS programs include ADG
- **Incentive Programs:** Grants, rebates, or other benefits for new ADG CHP installations
- **Economics:** The economics for ADG CHP can be very favorable when considering life cycle costs

ADG CHP systems provide financial and environmental benefits while producing efficient and reliable on-site heat and power. New CHP installations at WWTPs should be considered based on the size of the treatment plant, the treatment method (anaerobic digestion), and local economic factors. While many of the most desirable sites (i.e. large WWTPs in areas with high electricity prices) currently have installed CHP, there continues to be a significant amount of achievable potential for new CHP applications at WWTPs in the U.S.

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